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FACT SHEET NO. 4:

- LONG-TERM SAFETY OF ORAL CREATINE SUPPLEMENTATION -

Numerous papers have been published over the last years evaluating the long-term clinical safety of oral Creatine Monohydrate supplementation using CREAPURE™ (Degussa AG, Germany). The main focus was to evaluate if long-term CREAPURE™ supplementation (average of 5 grams/day) might increase incidence of musculoskeletal injury, heat related disorders (e.g. dehydration and cramping) and renal stress.

Clinical assessments included evaluating a comprehensive panel of serum and whole blood markers (electrolytes, muscle and liver enzymes, substrates, lipid profiles, red and white cells, etc.), renal function tests determined by Creatinine clearance, monitoring of injuries treated by the medical/athletic training staff, as well as collecting medical safety and fatigue inventories.

Results of these safety studies have consistently shown that in comparison to athletes who did not take Creatine, athletes who took Creatine *did not* experience greater incidence of injuries, heat related disorders (dehydration), cramping, musculoskeletal injuries, or gastrointestinal disturbances. Additionally, subjects taking Creatine *did not* experience significantly higher muscle and liver enzyme efflux, altered electrolytes, or increased renal stress determined by Creatine clearance.

Bibliography

A.1. 27th Annual Southeast American College of Sports Medicine Meeting, Norfolk, VA, February 5, 1999
RELATIONSHIP BETWEEN CREATINE SUPPLEMENTATION HISTORY AND MARKERS OF CLINICAL STATUS IN COLLEGE FOOTBALL PLAYERS
R.B. Kreider, C. Rasmussen, J. Ransom, C. Melton, J. Hunt, A.L. Almada, R. Tutko & P. Milnor, III. Exercise & Sport Nutrition Lab, Dept. of HMSE, The University of Memphis, Memphis, TN 38152.

Although no clinically significant side effects have been reported from creatine supplementation in the scientific literature, concern has been expressed regarding its long-term safety. This study examined the relationship between prior creatine use and markers of clinical status. 79 Division IA college football players (19.6±1 yrs, 72.5±3 in, 101.2±19 kg) completed creatine use history questionnaires; donated fasting blood and 24-h urine samples; had body composition determined using DEXA; and, had resting blood pressure and 12-lead ECGs performed. A comprehensive 31 panel clinical chemistry analysis was run on serum samples while whole blood samples were analyzed for cell blood counts. Serum creatine was also determined. A quantitative clinical urinalysis as well as creatine, creatinine, and creatinine clearance were determined from urine samples. The relationship between the subjects' history of taking creatine and markers of clinical status was analyzed by Pearson Product-Moment correlation analysis. In addition, subjects were classified as non-users (N, n= 22), former users (F, n=40) and current creatine users (C, n=17) and data were analyzed by one-way ANOVA with Bonferroni post-hoc analysis. Data are presented as means ± standard error of means for the N, F, and C groups respectively. Reported creatine use was 0.0±0, 5±1, and 11.3±3 months. Correlation analysis revealed that creatine use history (months) was significantly correlated to the blood urea nitrogen/creatinine ratio (r=0.24), serum phosphorus (r=-0.26), and the cholesterol/HDL ratio (r=0.25). When categorized as N, F, and C groups, creatine use was significantly correlated to serum globulin (r=-0.23), the albumin/globulin ratio (r=0.44), serum phosphorus (r=-0.33), monocytes (r=-0.26), serum creatine (r=0.32), and urine creatine (r=0.34). ANOVA revealed that serum (0.3±0.02, 0.4±0.04, 1.0±0.4 mg/dl) and urine (124±60, 266±170, 1,809±860 mg/24h) creatine levels were significantly greater (p>0.05) in the C group. In addition, serum phosphorus levels (4.2±0.1, 4.0±0.1, 3.7±0.2 mg/dl) in the C group was significantly lower than the N group. No significant differences were observed among groups in remaining serum metabolic variables, creatinine, muscle & liver enzymes, electrolytes, or hematological variables. No differences were observed in urine specific gravity, creatinine, or creatinine clearance. No significant differences were observed in body composition, resting heart rate, resting blood pressure, or ECG determined ventricular hypertrophy. All values were within normal ranges for athletes. Results indicate that current and former creatine use does not appear to significantly affect markers of clinical status although creatine use was weakly correlated to isolated variables.

A.2. 83rd Annual Experimental Biology Meeting
Washington DC, April 19, 1999
CREATINE SUPPLEMENTATION DURING PRE-SEASON FOOTBALL TRAINING DOES NOT AFFECT MARKERS OF RENAL FUNCTION
R. Kreider, J. Ransom, C. Rasmussen, J. Hunt, C. Melton, T. Stroud, E. Cantler & P. Milnor (Sponsor: S. Brown). Exercise & Sport Nutrition Lab, Department of HMSE, University of Memphis, Memphis, TN 38152.

This study examined the effects creatine supplementation on markers of renal function following two phases of preseason college football training. 53 Division IA football players (19.9±0.2 yrs; 185±1 cm, 103±2.6 kg) participated in the first phase of a long-term open label study. 34 subjects ingested a supplement containing 15.75 g/d of creatine for 5-d followed by 5.25 g/d of creatine for 20-d during pre-season conditioning. Remaining subjects were provided a carbohydrate/protein supplement containing no creatine. Training during phase I consisted of 4-5 d/wk (70±7 min per workout) of resistance/sprint conditioning while training during phase II involved subjects' practicing 2 to 3 times per day for 1.5 to 3.5 h (207±17 min/d, 6 d/wk) during 17-d of preseason football camp. During phase II, subjects in the creatine group ingested a carbohydrate/protein supplement containing 8.3 g/d of creatine. Prior to and following each phase of training, subjects donated fasting blood and 24-h urine samples. Serum and urinary creatine and creatinine were determined with renal function assessed by creatinine clearance. Data were analyzed by repeated measures ANOVA. Results revealed that serum and urinary creatine content was significantly greater in the creatine group ($p<0.05$). Additionally, significant differences were observed between groups in serum creatinine where creatinine levels decreased during training in the non-creatine subjects while not affected in the creatine group. No significant differences were observed between groups in urinary creatinine excretion or creatinine clearance. Results indicate that creatine supplementation during 25-d of preseason conditioning and 17-d of fall 2/3-a-day football camp does not affect markers of renal stress.

Reference:
Kreider, R., J. Ransom, C. Rasmussen, J. Hunt, C. Melton, T. Stroud, E. Cantler & P. Milnor. *Creatine supplementation during pre-season football training does not affect markers of renal function.* FASEB Journal. 13: A543, 1999.

A.3. 83rd Annual Experimental Biology Meeting
Washington DC, April 19, 1999
EFFECTS OF INGESTING CREATINE CONTAINING SUPPLEMENTS DURING TRAINING ON BLOOD LIPID PROFILES
C. Melton, R. Kreider, C. Rasmussen, J. Ransom, J. Hunt, T. Stroud, E. Cantler & P. Milnor (Sponsor: S. Brown). Exercise & Sport Nutrition Lab, Department of HMSE, University of Memphis, Memphis, TN 38152.

Creatine supplementation has been reported to improve lipid profiles in middle-aged subjects *(Earnest et al., Clin. Sci. 91:113-8, 1996)* and athletes *(Kreider et al., MSSE 30:73-82, 1998)*.

This study examined the effects creatine supplementation on lipid profiles following two phases of preseason college football training. 53 Division IA football players (19.9±0.2 yrs; 185±1 cm, 103±2.6 kg) participated in this open label safety study. 34 subjects ingested a supplement containing 15.75 g/d of creatine for 5-d followed by 5.25 g/d of creatine for 20-d. Remaining subjects were provided a carbohydrate/protein supplement with no creatine. Phase I training consisted of 4-5 d/wk (70±7 min per workout) of resistance/sprint conditioning while phase II training involved practicing 2 to 3 times per day for 1.5 to 3.5 h (207±17 min/d, 6 d/wk) during 17-d of preseason football camp. During phase II, subjects in the creatine group ingested a carbohydrate/protein supplement containing 8.3 g/d of creatine. Prior to and following each phase of training, subjects donated fasting blood samples. Lipid profiles were analyzed by repeated measures ANOVA and are expressed as mean±SEM percent changes from baseline values after 25- and 42-d of supplementation for the creatine and non-creatine groups, respectively. Results revealed significant interactions between groups in total cholesterol (-1±2, -10±2; 7±3, -2±2%, p=0.02) , triglycerides (10±10, 20±10; 42±13, 17±14%, p=0.03), LDL cholesterol (-1±3, -12±3; 9±4, 1±3%, p=0.008), and the cholesterol/HDL ratio (1±4, 3±4; 21±5, 19±5%, p=0.02). No significant differences were observed between groups in HDL. Results support previous reports that ingesting creatine or creatine containing supplements may affect blood lipid profiles.

Reference

Melton, C., R. Kreider, C. Rasmussen, J. Ransom, J. Hunt, T. Stroud, E. Cantler & P. Milnor. *Effects of ingesting creatine containing supplements during training on blood lipid profiles.* FASEB Journal. 13: A559, 1999.

A.4. 46th Annual American College of Sports Medicine Annual Meeting
Seattle, WA, June 3, 1999
CREATINE SUPPLEMENTATION DURING PRE-SEASON FOOTBALL TRAINING DOES NOT AFFECT FLUID OR ELECTROLYTE STATUS
C. Rasmussen, R. Kreider FACSM, J. Ransom, J. Hunt, C. Melton, T. Stroud, E. Cantler & P. Milnor. Exercise & Sport Nutrition Lab, Department of HMSE, University of Memphis, Memphis, TN 38152

Anecdotal reports suggest that creatine supplementation during intense training in the heat may alter electrolyte status and/or promote dehydration. This study examined the effects creatine supplementation on fluid and electrolyte status during two phases of pre-season college football training. 53 Division IA football players (19.9±0.2 yrs; 185±1 cm, 103±2.6 kg) participated in the first phase of a long-term open label study to evaluate the medical safety of creatine supplementation. 34 subjects ingested a commercially available supplement containing 15.75 g/d of creatine for 5-d followed by ingesting 5.25 g/d of creatine for 20-d. Remaining subjects were provided a carbohydrate/protein supplement containing no creatine. Supplements were administered following daily training sessions. Training during phase I consisted of 4-5 d/wk (70±7 min per workout) of resistance-training indoors (28±1EC, 79±2% RH) and sprint/agility conditioning outdoors (32±0.9EC, 84±3% RH). Training during phase II involved subjects practicing 2 to 3 times per day for 1.5 to 3.5 h (207±17 min/d, 6 d/wk) during 14-d of preseason football camp in which environmental conditions ranged from 29 to 37EC, 58 to 91% R.H. (33.7±0.6EC, 79±2.4%

R.H.). During phase II, subjects in the creatine group ingested a carbohydrate/protein supplement containing 8.3 g/d of creatine. Prior to and following each phase of training, body weight, total body water via bioelectrical impedance, fasting blood, and 24-hr urine samples were obtained. During camp, pre-and post practice body weights were recorded on all players (n=100). Data were analyzed by repeated measures ANOVA. Results revealed no significant interactions ($p>0.05$) between groups in total body weight, total body water; urine output, specific gravity; hematocrit, hemoglobin, blood volume, plasma volume or serum sodium, chloride, potassium, phosphorus, calcium, total protein, and albumin. No significant differences were observed between creatine users and non-users in weight bss (kg or %) during practices. Results indicate that creatine supplementation during 25-d of preseason conditioning and 14-d of football camp in an hot/humid environment does not affect markers of fluid or electrolyte status.

Reference

Rasmussen, C., R. Kreider, J. Ransom, J. Hunt, C. Melton, T. Stroud, E. Cantler & P. Milnor. *Creatine supplementation during pre-season football training does not affect fluid or electrolyte status.* Medicine and Science in Sport and Exercise. 31(5): S299, 1999.

A.5. 46th Annual American College of Sports Medicine Annual Meeting
Seattle, WA, June 4, 1999
EFFECTS OF CREATINE SUPPLEMENTATION DURING TRAINING ON MARKERS OF CATABOLISM AND MUSCLE & LIVER ENZYMES
J. Ransom, R. Kreider FACSM, J. Hunt, C. Melton, C. Rasmussen, T. Stroud, E. Cantler & P. Milnor. Exercise & Sport Nutrition Lab, Department of HMSE, University of Memphis, Memphis, TN 38152.

Muscle and/or liver enzymes have been reported to be increased in athletes taking creatine during training. This study examined the effects creatine supplementation on markers of catabolism and muscle/liver enzyme efflux following two phases of preseason college football training. 53 Division IA football players (19.9±0.2 yrs; 185±1 cm, 103±2.6 kg) participated in the first phase of a long-term open label study to evaluate the medical safety of creatine supplementation. 34 subjects ingested a commercially available supplement containing 15.75 g/d of creatine for 5-d followed by ingesting 5.25 g/d of creatine for 20-d. Remaining subjects were provided a carbohydrate/protein supplement with no creatine. Supplements were administered following daily workouts. Training during phase I consisted of 4-5 d/wk (70±7 min per workout) of resistance-training and sprint/agility conditioning. Training during phase II involved subjects' practicing 2 to 3 times per day for 1.5 to 3.5 h during 14-d of preseason football camp. During phase II, subjects in the creatine group ingested a carbohydrate/protein supplement containing 8.3 g/d of creatine. Prior to and following each phase of training, subjects donated fasting blood samples. Serum samples were analyzed for urea nitrogen (BUN), creatinine, uric acid, creatine kinase (CK), lactate dehydrogenase (LDH), aspartate aminotransferase (AST), and alanine amino transferase (ALT). Data were analyzed by repeated measures ANOVA. Results revealed that CK levels were mildly elevated in both groups. However, no significant differences were observed between creatine and non-creatine users in CK, LDH, ALT, or AST. No differences were observed between groups in BUN or uric acid levels. However, the ratio of BUN/creatinine (which serves as a general marker of anabolic/catabolic

status) was significantly increased in the non-creatine users group while being unchanged in the creatine group. Results indicate that creatine supplementation during two phases of preseason football training does not affect serum muscle & liver enzyme efflux and may allow an athlete to experience less catabolism.

Reference
Ransom, J., R. Kreider FACSM, J. Hunt, C. Melton, C. Rasmussen, T. Stroud, E. Cantler & P. Milnor. *Effects of creatine supplementation during training on markers of catabolism and muscle & liver enzymes.* Medicine and Science in Sport and Exercise. 31(5): S265, 1999.

A.6. 46th Annual American College of Sports Medicine Annual Meeting
Seattle, WA, June 5, 1999
CREATINE DOES NOT INCREASE INCIDENCE OF CRAMPING OR INJURY DURING PRE-SEASON COLLEGE FOOTBALL TRAINING I
R. Kreider FACSM, C. Melton, J. Hunt, C. Rasmussen, J. Ransom, T. Stroud, E. Cantler & P. Milnor. Exercise & Sport Nutrition Lab, Department of HMSE, University of Memphis, Memphis, TN 38152.

Anecdotal reports suggest that creatine supplementation during intense training increases the incidence of cramping and/or injury. This study examined the effects creatine supplementation on cramping/injury rates during two phases of preseason college football training. Division IA football players participated in this open label safety study. 34 of 77 athletes (44%) ingested a supplement containing 15.75 g/d of creatine for 5-d followed by 5.25 g/d of creatine for 20-d during pre-camp training. During the 14-d camp, 34 of 100 subjects (34%) ingested a carbohydrate/protein supplement containing 8.3 g/d of creatine. Remaining players were either former creatine users (> 1 month cessation) or non-users and were provided a carbohydrate/protein supplement containing no creatine. Pre-camp training consisted of 4-5 d/wk (70±7 min per workout) of resistance-training indoors (28±1EC, 79±2% RH) and sprint/agility conditioning outdoors (32±0.9EC, 84±3% RH). Subjects practiced 2 to 3 times per day (207±17 min/d, 6 d/wk) in environmental conditions ranging from 29 to 37EC, 58 to 91% RH (33.7±0.6EC, 79±2.4% RH). Injuries treated by the athletic training staff and missed practices due to injury were recorded. Data are presented as total number of treated injuries/complaints for creatine users/total occurrences and percentage occurrence rate for training phases I and II, respectively. Results revealed that the incidence of cramping (0/1, 0%; 17/49, 35%), heat/dehydration (0/0, 0%; 3/8, 38%), muscle tightness (1/3, 33%; 5/12, 42%), muscle pulls/strains (0/3, 0%; 1/7, 14%), non-contact joint injuries (0/1, 0%; 7/22, 32%), contact injuries (0/0, 0%; 4/11, 36%), illness (0/0, 0%, 1/10, 10%), number of missed practices due to injury (0/0, 0%, 26/70, 38%), and total injuries/missed practices (1/8, 13%; 64/188, 34%) were generally proportional or lower than the creatine use rate among players during pre-camp conditioning (44%) and fall camp (34%). Results indicate that creatine supplementation during pre-season college football training in hot/humid environmental conditions does not increase the incidence of muscle cramping or injury.

Reference
Kreider, R., C. Melton, J. Hunt, C. Rasmussen, J. Ransom, T. Stroud, E. Cantler & P. Milnor. *Creatine does not increase incidence of cramping or injury during pre-season college football training I.* Medicine and Science in Sport and Exercise. 31(5): S355, 1999.

A.7. 46th Annual American College of Sports Medicine Annual Meeting
Seattle, WA, June 5, 1999
CREATINE DOES NOT INCREASE INCIDENCE OF CRAMPING OR INJURY DURING PRE-SEASON COLLEGE FOOTBALL TRAINING II
J. Hunt, R. Kreider FACSM, C. Melton, J. Ransom, C. Rasmussen, T. Stroud, E. Cantler & P. Milnor. Exercise & Sport Nutrition Lab, Department of HMSE, University of Memphis, Memphis, TN 38152.

This study examined the effects creatine supplementation on the incidence of injury during preseason football training in relation to the percentage of creatine use among players. Division IA football players participated in this open label safety study. 34 of 77 athletes ingested a supplement containing 15.75 g/d of creatine for 5-d followed by 5.25 g/d of creatine for 20-d during pre-camp training. During the 14-d camp, 34 of 100 subjects ingested a carbohydrate/protein supplement containing 8.3 g/d of creatine. Remaining players were either former creatine users (> 1 month cessation) or non-users and were provided a carbohydrate/protein supplement containing no creatine. Pre-camp training consisted of 4-5 d/wk (70±7 min per workout) of resistance-training indoors (28±1EC, 79±2% RH) and sprint/agility conditioning outdoors (32±0.9EC, 84±3% RH). Subjects practiced 2 to 3 times per day (207±17 min/d, 6 d/wk) in environmental conditions ranging from 29 to 37EC, 58 to 91% RH (33.7±0.6EC, 79±2.4% RH). Injuries treated by the athletic training staff were recorded and categorized as cramping, heat/dehydration, muscle tightness, muscle strains/pulls, non-contact joint injuries, contact injuries, and illness. In addition, the number of missed practices due to injury/illness were recorded. The percentage rate of occurrence for each category were calculated for creatine and non-creatine users. These rates were then subtracted from the usage rates of creatine among athletes during pre-camp (44%) and camp (34%) training phases. The values were then analyzed by paired t-tests and 2x2 ANOVA. Results revealed that overall injury incidence rate in the creatine users was significantly lower (14±6%, p=0.003) than the creatine use rate (34%). Further, that a significant interaction (p=0.003) was observed between groups with injury rates in the creatine group 36±7% lower than use rate during pre-camp training and 3.4±5% lower than use rates during camp. An inverse relationship was observed in the non-users group. Results indicate that creatine supplementation during intense training may reduce the incidence of injury particularly during the pre-camp training phase.

Reference
Hunt, J., R. Kreider, C. Melton, J. Ransom, C. Rasmussen, T. Stroud, E. Cantler & P. Milnor. *Creatine does not increase incidence of cramping or injury during pre-season college football training II.* Medicine and Science in Sport and Exercise. 31(5):S355, 1999.

A.8. 22nd Annual National Strength & Conditioning Association Meeting
Kansas City, MO, June 25, 1999
CREATINE SUPPLEMENTATION DOES NOT INCREASE INCIDENCE OF CRAMPING OR INJURY DURING COLLEGE FOOTBALL TRAINING I
R.B. Kreider, C. Melton, J. Ransom, C. Rasmussen, T. Stroud, E. Cantler, M. Greenwood & P. Milnor. Exercise & Sport Nutrition Laboratory, Department of HMSE, University of Memphis, Memphis, TN 38152.

Anecdotal reports suggest that creatine supplementation during intense training may increase the incidence of muscle cramping and/or injury. This study examined the effects of creatine supplementation on cramping/injury rates during pre-season and in-season college football training. 100 division IA football players participated in this open label safety study. 34 of 77 athletes (44%) ingested creatine containing supplements (15.75 g/d for 5-d followed by 5.25 g/d for 20-d) during pre-season supervised training. During 14-d of 2/3 a day camp, 34 of 100 athletes (34%) ingested a carbohydrate/protein supplement containing 8.3 g/d of creatine. During the season, these athletes ingested supplements containing 5.25 g/d of creatine. Following camp, 25 additional athletes ingested creatine containing supplements (15.75 g/d for 5-d, 5.25 g/d thereafter). This resulted in a total of 59 of 98 players (60%) ingesting creatine during the season. During the season, 24/59 (41%) creatine users were 1st team starters at some point. Injuries treated by the athletic training staff and missed practices due to injury were recorded for all athletes. Data are presented as the total number of treated injuries for creatine users/total injuries and percentage occurrence rate for pre-season, camp, and in-season training phases, respectively. Results revealed that the incidence of cramping (0/1, 0%; 17/49, 35%; 11/15, 73%), heat/dehydration (0/0, 0%; 3/7, 43%; 1/1, 100%), muscle tightness (1/2, 50%; 5/11, 45%; 2/5, 40%), muscle pulls/strains (0/3, 0%; 1/6, 17%; 6/9, 67%), non-contact joint injuries (0/1, 0%; 6/16, 38%; 19/38, 50%), contact injuries (0/0, 0%; 4/11, 36%; 18/24, 75%), illness (0/0, 0%; 1/7, 14%, 5/9, 56%), number of missed practices due to injury (0/0, 0%; 12/47, 26%, 14/36, 39%), players lost for the season (0/0, 0%; 0/1, 0%; 1/2, 50%), and total injuries/missed practices (1/8, 13%; 49/155, 32%; 77/139, 55%) were generally lower or proportional to the creatine use rate among players. These findings indicate that creatine supplementation during college football training does not increase the incidence of injury or cramping.

Reference

Kreider, R., C. Melton, J. Ransom, C. Rasmussen, T. Stroud, E. Cantler, M. Greenwood & P. Milnor. *Creatine Supplementation does not increase incidence of cramping or injury during college football training I.* Journal of Strength and Conditioning Research. 13: 428, 1999.

A.9. 22nd Annual National Strength & Conditioning Association Meeting
Kansas City, MO, June 25, 1999
CREATINE SUPPLEMENTATION DOES NOT INCREASE INCIDENCE OF CRAMPING OR INJURY DURING COLLEGE FOOTBALL TRAINING II

M. Greenwood, R.B. Kreider, C. Rasmussen, J. Ransom, C. Melton, T. Stroud, E. Cantler, & P. Milnor. Exercise & Sport Nutrition Laboratory, Department of HMSE, University of Memphis, Memphis, TN 38152.

This study examined whether creatine supplementation during college football training results in a disproportionate increase in injury rates in comparison to the percentage of creatine use among players. 100 division IA football players participated in this open label safety study. 34 of 77 athletes (44%) ingested creatine containing supplements (15.75 g/d for 5-d followed by 5.25 g/d for 20-d) during pre-camp supervised training. During 14-d of 2/3 a day camp, 34 of 100 athletes (34%) ingested a carbohydrate/protein supplement containing 8.3 g/d of creatine. During the season, these athletes ingested supplements containing 5.25 g/d of creatine. Following camp, 25 additional athletes ingested creatine containing supplements (15.75 g/d for 5-d, 5.25 g/d thereafter) for a total of 59 of 98 players (60%) ingesting creatine during the season. Injuries treated by the athletic training staff and missed practices due to injury were recorded for all athletes and categorized as cramping, heat/dehydration, muscle tightness, muscle strains/pulls, non-contact joint injuries, contact injuries, illness, missed practices due to injury, and athletes lost for the season due to injury. The percentage rate of occurrence for each category was calculated for creatine and non-creatine users. The rates of creatine used during pre-camp (44%), camp (34%), and in-season (60%) training phases were then subtracted from the observed injury rates. Data were analyzed 2x3 ANOVA, LSD post-hoc analysis, and paired t-tests. Data are presented as mean ± SEM percent differences between creatine use rate and percentage of total injuries observed for the above categories for the pre-camp, camp, and in-season training phases, respectively. Results revealed that observed injury rates in the creatine users was generally lower than the creatine use rate for each phase of training (-36±9, -6±6, 1±6 %). Further, that creatine users experienced a 6±5% lower ($p=0.001$) incidence of injury in comparison to their use rate. Results indicate that in comparison to the creatine use rate of these athletes, creatine does not increase the incidence of injury.

Reference

Greenwood, M., R. Kreider, J. Ransom, C. Rasmussen, C. Melton, T. Stroud, E. Cantler, & P. Milnor. *Creatine Supplementation does not increase incidence of cramping or injury during college football training II.* Journal of Strength and Conditioning Research. 13: 425-426, 1999.

A.10. 22nd Annual National Strength & Conditioning Association Meeting
Kansas City, MO, June 25, 1999
EFFECTS OF LONG-TERM CREATINE SUPPLEMENTATION DURING TRAINING ON MARKERS OF CATABOLISM AND ENZYME EFFLUX

J. Ransom, R. Kreider, C. Rasmussen, C. Melton, T. Stroud, E. Cantler, M. Greenwood & P. Milnor. Exercise & Sport Nutrition Laboratory, Department of HMSE, University of Memphis, Memphis, TN 38152.

Some studies indicate that creatine supplementation during training may increase muscle and/or liver enzyme efflux. This study examined the effects of long-term creatine supplementation on markers of catabolism and muscle/liver enzyme efflux in athletes who supplemented their diet with creatine for 18-wk during preseason and in-season college football training. 49 division IA football

players participated in this long-term open label study to evaluate the medical safety of creatine supplementation. 33 subjects ingested supplements containing 15.75 g/d of creatine for 5-d, 5.25 g/d of creatine for 20-d, 8.3 g/d of creatine for 14-d, and 5.25 g/d of creatine for 87-d. 16 subjects served as controls and were provided a carbohydrate/protein supplement with no creatine. Supplements were administered following daily workouts. Training involved 4-5 d/wk (70±7 min/d) of resistance-training and sprint/agility conditioning during pre-camp training, practicing 2 to 3 times per day for 14-d during preseason football camp (207±17 min/d, 6 d/wk), and practicing/playing (127±8 min/d, 6 d/wk) during in-season training. Prior to and following each phase of training, subjects donated fasting blood samples. Serum samples were analyzed for urea nitrogen (BUN), creatinine, uric acid, creatine kinase (CK), lactate dehydrogenase (LDH), aspartate aminotransferase (AST), and alanine aminotransferase (ALT). Data were analyzed by repeated measures ANOVA with LSD post-hoc analysis. Results revealed no significant differences ($p>0.05$) between creatine users and non-users in serum BUN, creatinine, CK, LDH, AST, or ALT levels. However, the ratio of BUN/creatinine (which serves as a general marker of anabolic/catabolic status) was significantly higher in the non-creatine users group following phase I & II of training while being unchanged in the creatine group. Results indicated that creatine supplementation during pre-season and in-season college football training does not adversely affect serum muscle & liver enzyme efflux and may allow an athlete to experience less catabolism during intense periods of training.

Reference

Ransom, J., R. Kreider, C. Rasmussen, C. Melton, T. Stroud, E. Cantler, M. Greenwood & P. Milnor. *Effects of long-term creatine supplementation during training on markers of catabolism and enzyme efflux.* Journal of Strength and Conditioning Research. 13: 431, 1999.

A.11. 22nd Annual National Strength & Conditioning Association Meeting
Kansas City, MO, June 25, 1999
LONG-TERM CREATINE SUPPLEMENTATION DURING FOOTBALL TRAINING DOES NOT AFFECT MARKERS OF RENAL STRESS
C. Rasmussen, R. Kreider, C. Melton, J. Ransom, T. Stroud, E. Cantler, M. Greenwood & P. Milnor. Exercise & Sport Nutrition Laboratory, Department of HMSE, The University of Memphis, Memphis, TN 38152.

Anecdotal concerns have suggested that creatine supplementation may increase renal stress. This study examined the effects of long-term creatine supplementation on markers of renal function in athletes who supplemented their diet with creatine for 18-wk during preseason and in-season college football training. 48 division IA football players participated in this long-term open label study to evaluate the medical safety of creatine supplementation. Thirty-three (33) subjects ingested supplements containing 15.75 g/d of creatine for 5-d, 5.25 g/d of creatine for 20-d, 8.3 g/d of creatine for 14-d, and 5.25 g/d of creatine for 87-d. Fifteen (15) subjects served as controls and were offered a carbohydrate/protein supplement with no creatine. Supplements were administered following daily workouts. Prior to and following each phase of training, subjects donated fasting blood and 24-h urine samples. Serum samples were analyzed for creatinine levels while urine samples were analyzed for creatine and creatinine concentrations. Renal function was assessed by

analyzing creatinine excretion and creatinine clearance. Data were analyzed by repeated measures ANOVA with LSD post-hoc analysis. Results revealed that urinary creatine content was significantly greater in the creatine group ($p<0.05$). However, no significant differences were observed between groups in serum creatinine, urine volume, specific gravity, urinary creatinine excretion (expressed as total grams or g/L), or creatinine clearance. Results indicate that creatine supplementation during 18-wk of preseason and in-season college football training does not adversely affect markers of renal stress.

Reference
Rasmussen, C., R. Kreider, C. Melton, J. Ransom, T. Stroud, E. Cantler, M. Greenwood & P. Milnor. *Long-term creatine supplementation during football training does not affect markers of renal stress.* Journal of Strength and Conditioning Research. 13: 431, 1999.

A.12. 22nd Annual National Strength & Conditioning Association Meeting
Kansas City, MO, June 25, 1999
EFFECTS OF CREATINE SUPPLEMENTATION DURING IN-SEASON COLLEGE FOOTBALL TRAINING ON MARKERS OF CLINICAL STATUS
C. Melton, R.B. Kreider, C. Rasmussen, J. Ransom, T. Stroud, E. Cantler, M. Greenwood, P. Milnor, and A.L. Almada. Exercise and Sport Nutrition Laboratory, Department of HMSE, The University of Memphis, Memphis, TN 38152.

Anecdotal reports have suggested that long-term creatine supplementation may pose negative health effects. 46 division IA college football players participated in this open label safety study designed to evaluate the medical safety of creatine supplementation during training. Following fall football 2/3-a-day camp, 21 athletes (mostly freshman with no recent history of creatine use) were administered supplements containing 15.75 g/d of creatine for 5-d followed by ingesting 5.25 g/d of creatine for the remainder of in-season training (82-d). 25 athletes served as control subjects and were offered a post-workout carbohydrate/protein supplement containing no creatine. Body mass, total body water (BIA), body composition (DEXA), blood pressure, fasting blood samples, and 24-hour urine samples were obtained prior to and following 87-d of in-season training. Data were analyzed by ANOVA for repeated measures with LSD post-hoc analysis and are presented as mean±SEM changes from pre-supplementation values for the non-creatine (NC) and creatine (Cr) groups, respectively. Results revealed no significant differences between groups in total body water (%) or blood pressure. Gains in body mass (0.65±0.6; 2.52±0.6 kg, $p=0.04$) and FFM (0.92±0.2; 2.35±0.2 kg, $p=0.002$) were greater in the Cr group while changes in body fat (0.6±0.3; -0.3±0.3 %, $p=0.04$) were more favorable in the Cr group. Serum creatinine levels were increased to a greater degree in the Cr group (0.21±0.03; 0.34±0.03 mg/dl, $p=0.008$). However, no significant differences were observed in serum muscle and liver enzyme efflux, electrolytes, glucose, total protein, the albumin/globulin ratio, total bilirubin, blood lipids, hematocrit, hemoglobin, red cell status, or percentage of lymphocytes. Additionally, no significant differences were observed between groups in markers of renal function including urine volume, specific gravity, urine creatinine, or creatinine clearance. These findings indicate that creatine supplementation during in-season football training may favorably affect body composition alterations but does not adversely affect markers of health status.

Reference
Melton, C., R. Kreider, C. Rasmussen, J. Ransom, T. Stroud, E. Cantler, M. Greenwood & P. Milnor. *Effects of creatine supplementation during in-season college football training on markers of clinical status.* Journal of Strength and Conditioning Research. 13: 429-430, 1999.

A.13. 19th Southwest American College of Sports Medicine Meeting
San Jose, CA, November 12, 1999
LONG-TERM CREATINE SUPPLEMENTATION DOES NOT AFFECT MARKERS OF RENAL STRESS IN ATHLETES
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Concerns have been expressed that long-term creatine supplementation may impair renal function. This study examined the effects of 9-months of creatine supplementation on markers of renal function in athletes. 60 division IA football players participated in an open label study to evaluate the long-term medical safety of creatine supplementation. 44 subjects were administered 15.75 g/d of creatine for 5-d and 5 to 8 g/d of creatine for 9-months following workouts. 16 athletes served as controls. At 0, 1, 1.5, 4, 6, and 9 months of training, subjects donated fasting blood and 24-h urine samples. Renal function was assessed by analyzing urinary creatinine excretion and creatinine clearance. Data were analyzed by repeated measures ANOVA with LSD post-hoc analysis. Results revealed that subjects ingesting creatine had higher mean serum creatine, urinary creatine, and serum creatinine levels than non-users ($p<0.01$). However, no significant group x time interactions were observed in serum creatine, serum creatinine, urinary creatine, urinary creatinine, or creatinine clearance. Results indicate that creatine supplementation during 9-months of college football training does not adversely affect markers of renal stress.

Reference
Kreider, R., C. Rasmussen, J. Ransom, C. Melton, M. Greenwood, T. Stroud, E. Cantler, P. Milnor, A. Almada, P. Greenhaff. *Long-term creatine supplementation does not affect markers of renal stress in athletes.* Sports Medicine, Training and Rehabilitation. In press, 2000.

A.14. 19th Southwest American College of Sports Medicine Meeting
San Jose, CA, November 12, 1999
LONG-TERM CREATINE SUPPLEMENTATION DOES NOT AFFECT MUSCLE OR LIVER ENZYME EFFLUX IN ATHLETES
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Concerns have been expressed that bng-term creatine supplementation may increase muscle and/or liver stress. This study examined the effects of 9-months of creatine supplementation on

markers of renal function in athletes. 60 division IA football players participated in an open label study to evaluate the long-term medical safety of creatine supplementation. 44 subjects were administered 15.75 g/d of creatine for 5-d and 5 to 8 g/d of creatine for 9-months following workouts. 16 athletes served as controls. At 0, 1, 1.5, 4, 6, and 9 months of training, subjects donated fasting blood for determination of muscle and liver enzyme efflux. Data were analyzed by repeated measures ANOVA with LSD post-hoc analysis. Results revealed that although mean serum creatinine levels were significantly higher during training in the creatine group (1.34±0.01 vs. 1.27±0.02 mg/dl, p=0.01), no significant group or group x time effects were observed in blood urea nitrogen (BUN), aspartate aminotransferase (AST), alanine aminotransferase (ALT), lactate dehydrogenase (LDH), or creatine kinase (CK) levels. Results indicate that creatine supplementation during 9-months of college football training does not increase markers of muscle or liver stress.

Reference

Almada, A., Kreider, R., J. Ransom, C. Melton, C. Rasmussen, M. Greenwood, T. Stroud, E. Cantler, P. Milnor, C. Earnest. *Long-term creatine supplementation does not affect muscle or liver enzyme efflux in athletes.* Sports Medicine, Training and Rehabilitation. In press, 2000.

A.15. 47th Annual American College of Sports Medicine Annual Meeting
Indianapolis, IN, June 2-5, 2000
LONG-TERM CREATINE SUPPLEMENTATION DOES NOT ADVERSLEY AFFECT CLINICAL MARKERS OF HEALTH
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Creatine has been reported to increase strength and fat free mass gains during training. However, concerns have been expressed over the long-term side effects of creatine supplementation. Approximately 100 division IA football players participated in an open label study to evaluate the long-term medical safety of creatine supplementation. Athletes who wished to ingest creatine during training were administered creatine following workouts for 12-months (15.75 g/d for 5-d and » 5 g/d thereafter). Fasting blood and 24-h urine samples were collected at 0, 1, 1.5, 4, 6, 9, and 12 months of supplementation and compared to samples from subjects who did not take creatine during training, After 12-months of supplementation, samples were obtained from 17 creatine and 17 control athletes. A 49-item clinical chemistry panel was run on blood and urine samples and analyzed by MANOVA. Multivariate analysis revealed no significant differences between creatine users and non-users in the clinical panel evaluated (p=0.36). Additionally, univariate analysis revealed no significant differences in serum creatinine, urea nitrogen, uric acid, serum muscle and liver enzymes, blood lipids, electrolytes, percentage of whole blood red and white cells, or urine specific gravity. There was also no evidence of greater incidence of injury or cramping during training. These findings indicate that creatine supplementation does not adversely affect markers of health status in comparison to athletes undergoing similar training.

Reference

Kreider, R. C. Rasmussen C. Melton, M. Greenwood, T. Stroud, J., Ransom, E. Cantler, P. Milnor, & A. Almada. *Long-term creatine supplementation does not adversely affect markers of clinical status.* Medicine and Science in Sport and Exercise. 32(5): In press, 2000.

A.16. 23rd Annual National Strength & Conditioning Association Meeting
Orlando, FL, June 23, 2000
SHORT AND LONG-TERM CREATINE SUPPLEMENTATION DOES NOT AFFECT HEMATOLOGICAL MARKERS OF HEALTH
M. Greenwood, R. Kreider, C. Melton, C. Rasmussen, J. Lundberg, T. Stroud, E. Cantler, P. Milnor, & A. Almada. Exercise & Sport Nutrition Laboratory, Department of HMSE, University of Memphis, Memphis, TN 38152

Creatine supplementation has been reported to increase strength and fat-free mass. However, concerns have been raised over the long-term medical safety of creatine supplementation. This study examined the effects of short- and long-term creatine supplementation on hematological markers of health status in NCAA Division IA football players. Over a 15-month period, athletes were administered creatine or creatine-free containing supplements following training sessions. Subjects who ingested creatine were administered 15.75 g/d of creatine monohydrate for 5-d and an average of 5 g/d thereafter. At the end of the 1999 season, fasting whole blood and serum samples were obtained from 15 control athletes, 12 athletes who had taken creatine for 3 months, and 16 athletes who had taken creatine for 15 months. A 41-item comprehensive clinical chemistry panel was run on whole blood and serum samples. MANOVA revealed no significant differences among creatine non-users, short-term creatine users, and long-term creatine users in hematological markers ($p=0.60$). Additionally, univariate ANOVA analysis revealed no significant differences in serum creatinine, urea nitrogen, uric acid, serum muscle and liver enzymes, blood lipids, electrolytes, or percentage of whole blood red and white cells. These findings indicate that short (3 months) and long-term (15 months) creatine supplementation does not adversely affect hematological markers of health status in comparison to athletes who do not take creatine.

Reference
Greenwood, M., R. Kreider, C. Melton, C. Rasmussen, J. Lundberg, T. Stroud, E. Cantler, P. Milnor, & A. Almada. *Short and long-term creatine supplementation does not affect hematological markers of health.* Journal of Strength and Conditioning Research. 14: In press, 2001.

A.17. 23rd National Strength & Conditioning Association Meeting
Orlando, FL, June 23, 2000
LONG-TERM CREATINE SUPPLEMENTATION DOES NOT AFFECT MARKERS OF RENAL STRESS IN ATHLETES
A. Almada, R. Kreider, C. Melton, C. Rasmussen, J. Lundberg, J. Ransom, M. Greenwood, T. Stroud, E. Cantler, P. Milnor, J. Fox. Exercise & Sport Nutrition Lab, Department of HMSE, University of Memphis, Memphis, TN 38152; MetaResponse Sciences, Aptos, CA; and, School of Biomedical Sciences, University of Nottingham, England.

This study examined the effects of long-term creatine supplementation on markers of renal function in athletes. Over a 12-month period, athletes were administered creatine or non-creatine containing supplements following training sessions. Subjects who ingested creatine were administered 15.75 g/d of creatine monohydrate for 5-d and an average of 5 g/d thereafter. At the beginning of the 1999 season, 49 athletes (19.1± 1 yrs, 103± 3 kg) donated fasting blood and 24 hour urine samples. Of these subjects, 27 athletes had taken creatine in a supervised manner for 12 months (Cr) and 22 athletes had no history of creatine use (CON). Creatine and creatinine concentrations were determined on plasma and urine samples. Renal function was assessed by creatinine clearance. Data were analyzed by repeated measures ANOVA and are presented as means ± SEM. Results revealed that subjects in the Cr group had significantly higher plasma creatine levels (Cr 201±31; CON 126±8 Umol/L, p=0.04) and urine creatine levels (Cr 10.4±1.1; CON 6.0±1.2 Umol/L, p=0.01) while tending to have higher plasma creatinine levels (Cr 136±13; CON 110±5 Umol/L, p=0.08) than non-users. However, no significant differences were observed between groups in urinary creatinine excretion (Cr 24.4±1.0; CON 22.7±1.1 mmol/L, p=0.24) or creatinine clearance (Cr 161±9; CON 175±14 ml/min, p=0.38). Results indicate that 12 months of creatine supplementation during college football training does not adversely affect markers of renal stress in comparison to athletic controls.

A.18. 47th American College of Sports Medicine Annual Meeting
Indianapolis, IN, June 2-5, 2000
EFFECTS OF CREATINE SUPPLEMENTATION ON THE INCIDENCE OF CRAMPING/INJURY DURING COLLEGIATE FALL BASEBALL
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Anecdotal reports suggest that creatine supplementation during intense training may increase the incidence of muscle cramping and/or injury. This study examined the effects of creatine supplementation on cramping/injury rates during a 24 day training period. Thirty-nine Division I baseball players participated in this study. Twenty-one (54%) of the thirty-nine athletes reported ingesting 15 to 25g/d of creatine for 5 d followed by 5 g/d of creatine for the 24 day training period. All athletes (creatine users/non-users) also had access to a carbohydrate supplement containing no creatine during the training period. Subjects practiced once a day (231± 24 min/d, 6 d/wk) in environmental conditions ranging from 27 to 35 C, 59 to 91% RH (30.4 ± 0.6 C, 77 ± 2.5% RH). Injuries treated by the athletic training staff were recorded and categorized as cramping, heat/dehydration, muscle tightness, muscle strains/pulls, noncontact injuries joint injuries, contact injuries, and illness. The number of practices missed due to injury/illness were also recorded. Data are presented as the total number of treated injuries for creatine users/total injuries and percentage occurrence rate for the 24 day training sessions. Results revealed that the incidence of cramping (0/0, 0%), heat/dehydration (0/0, 0%), muscle tightness (5/15, 33%), muscle pulls/strains (2/5, 40%), non-contact joint injuries (3/8, 38%), contact injuries (1/3, 33%), illness (3/1, 67%), number of missed practices due to injury (2/6, 33%), players lost for the season (0/0, 0%), and total injuries/missed practices (16/38, 42%) were generally lower or proportional to the creatine use rate

among players. These findings indicate that creatine supplementation during collegiate fall baseball does not increase the incidence of injury or cramping.

A.19. 47th American College of Sports Medicine Annual Meeting
Indianapolis, IN, June 2-5, 2000
EFFECTS OF CREATINE SUPPLEMENTATION ON THE INCIDENCE OF CRAMPING/ INJURY DURING A COLLEGE FOOTBALL SEASON
Greenwood L, Greenwood M, Kreider R, Carroll R: Arkansas State University, Jonesboro, AR.

Anecdotal reports suggest that creatine supplementation during intense training may increase the incidence of muscle cramping and/or injury. The purpose of this study was to examine the effects of creatine supplementation on cramping/injury rates during the college football season. Seventy -two Division IA football players participated in this season long safety study. Before and/or during the first week of training, 38 (53%) of the seventy-two athletes reported ingesting 20 to 30 g/d of creatine for 5/7-d followed by 5 to 10 g/d of creatine during the competitive season. All athletes (creatine users/non-users) also had access to a carbohydrate supplement containing no creatine during the training/competitive seasons. Subjects practiced or played in environmental conditions ranging from 57 to 97 F, 30 to 86% RH (79.94 $\pm$ 9.84 F, 47.79 $\pm$ 11.17% RH). During the season, 27/38 (71%) creatine users were first team starters at some point. Injuries treated by the athletic training staff were recorded and categorized as cramping, heat/dehydration, muscle tightness, muscle strains/pulls, non-contact joint injuries, contact injuries, and illness. The number of practices missed due to injury/illness were also recorded. Data are presented as the total number of treated injuries for creatine users/total injuries and percentage occurrence rate for in-season practice/competitive phases. Results revealed that the incidence of cramping (5/11, 45%), heat/dehydration (0/1, 0%), muscle tightness (6/18, 33%), muscle pulls/strains (21/40, 53%), non-contact joint injuries (19/46, 41%), contact injuries (81/154, 53%), illness (23/57, 40%), number of missed practices due to injury (41/96, 43%), players lost for the season (1/1, 100%), and total injuries/missed practices (197/424, 47%) were generally lower or proportional to the creatine use rate among players. These findings indicate that creatine supplementation during a Division I college football season does not increase the incidence of injury or cramping.

A.20. National Athletic Trainer's Association Annual Meeting
Nashville, TN, June, 2000
CREATINE SUPPLEMENTATION PATTERNS AND PERCEIVED EFFECTS AMONG DIVISION I ATHLETES
Greenwood M, Kreider R, Greenwood L: Arkansas State University, Jonesboro, AR.

There is limited information in the literature regarding the dosages and schedules of creatine use with athletes outside of controlled research settings. The purpose of this study was to investigate the patterns of creatine supplementation and its perceived effects among Division I athletes. Two hundred and nineteen Division I athletes (male n=156, female n=63) participated in a study designed to determine the patterns of creatine use among varsity intercollegiate athletes. Subjects voluntarily completed an anonymous questionnaire regarding creatine use and perceived side

effects attributed to creatine use. Ninety athletes (41%) indicated previous, or current creatine use (male n=88, female n=2). These athletes represented six varsity sports and were considered creatine users (CrU) in the analysis of the survey. Based on literature reviews, recommended dosage guidelines used in this study were 0.3 g/kg/d for five to seven days in the loading phase and 0.03 g/kg/d during training in the maintenance phase. Eighty-three (92%) CrU considered creatine supplementation safe, while six did not, and one respondent did not know. CrU reported taking dosages of 0.03 ± .24g/kg (mean ± SD) of creatine during loading phases for 6.6 ± 10.2 days. CrU reported taking maintenance dosages of 0.15 ± 0.14g/kg for 101 ± 195 days. Regarding perceived positive effects of creatine use, 80 CrU (89%) noticed weight gains, 73 (81%) indicated quicker recovery from intense workouts, and 42 (47%) had strength increases. These CrU were above, at, or below recommended dosage levels for loading (0.31 ± 0.25g/kg/d) and maintenance (0.16 ± 0.15g/kg/d) phases. Thirty-four (38%) CrU reported GI distress and/or muscle cramping which they related to creatine use (load = 0.35 ± 0.30g/kg/d; maintenance = 0.19 ± 0.17g/kg/d). Ironically, the 34 CrU that noted perceived negative side effects also noted perceived positive effects. Overall, 10 CrU (11%) reported no ergogenic effects with creatine supplementation in either the loading (0.25 ± 0.19g/kg/d) and/or maintenance (0.09 ± 0.06g/kg/d) phases. Results from this study indicated that there were highly variable methods of creatine use according to dosages and days based on body weight. While positive effects were noted, improper use also appeared to influence perceived negative effects. Based on the information attained in this study, athletes are in need of education regarding proper use of creatine supplementation as part of their overall nutritional regimen.

A.21. EFFECTS OF LONG-TERM CREATINE SUPPLEMENTATION ON RENAL FUNCTION AND MUSCLE & LIVER ENZYME EFFLUX

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Creatine has been reported to be an effective ergogenic aid. However, concerns have been raised regarding the long-term safety of creatine supplementation. This study examined the effects of long-term creatine supplementation on renal function and muscle/liver enzyme efflux. Over a 21 month period, 94 Division IA college football players (19±1 yrs, 103±3 kg) were administered in an open label manner creatine or non-creatine containing supplements following training sessions. Subjects who ingested creatine were administered 15.75 g/d of creatine monohydrate for 5-d and an average of 5 g/d thereafter. Fasting blood and 24-hour urine samples were collected at 0, 1, 1.5, 4, 6, 10, 12, 17, and 21 months of training. At the end of the study, subjects were categorized into groups that did not take creatine (n=44) and subjects who took creatine for 0-6 months (mean 5.0±1.8 months, n=12), 7-12 months (mean 9.4±3.6 months, n=25), and 12-21 months (mean 18.1±3.0 months, n=13). Baseline and the subjects' last blood and urine samples were analyzed by repeated measures ANOVA. Results revealed that creatine supplementation had no significant effects on serum creatinine, urinary creatinine excretion, creatinine clearance, blood urea nitrogen (BUN), BUN/creatinine ratio, CK, LDH, AST, or ALT. These findings support contentions that short and long-term creatine supplementation does not adversely affect renal function or markers of muscle & liver damage.

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